NATIONAL BUREAU OF STANDARDS REPORT

7021

AIR DELIVERY AND ARRESTANCE TESTS OF
A "SUNFLO" AIR PURIFIER, MODEL SF-2

Manufactured by
Modern Aids, Inc.
New York 23, New York

by

Carl W. Coblentz
and
Paul R. Achenbach

Report to

Bureau of Medicine
Food and Drug Administration
Department of Health, Education and Welfare
Washington 25, D. C.

NBS

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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C. W. Coblentz and P. R. Achenbach
Mechanical Systems Section
Building Research Division

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1. INTRODUCTION

At the request of the Bureau of Medicine, Food and Drug Administration, Department of Health, Education and Welfare, tests were made of the air cleaning characteristics of a "Sunflo" air purifier manufactured by Modern Aids, Inc., New York 23, New York. The scope of this investigation was limited to measurements of the arrestance of atmospheric dust, the air delivery of the unit with a clean filter, and also with a filter loaded with Cottrell precipitate, and qualitative observations of the arrestance of ragweed pollen and tobacco smoke.

2. DESCRIPTION OF TEST SPECIMEN

The test specimen was a "Sunflo Flowing Air Purifier," Model SF-2, manufactured by Modern Aids, Inc., New York 23, New York. It was supplied to the National Bureau of Standards by the Bureau of Medicine, Food and Drug Administration. It had a glossy black plastic case, about 13 in. wide, 7 in. high, and 6 in. deep, and resembled a portable radio in appearance. A perforated sheet steel grille covered almost all of the front side of the case. The perforations consisted of horizontal slots, approximately 1/16 in. by 7/16 in., with webs 1/8 in. wide separating adjacent slots, both vertically and horizontally. The major portion of this grille was covered up from the inside, leaving a 6 in. diameter area in the center for the discharge of air.

The entire back side of the cabinet was occupied by the air filter which consisted of a thin sheet of unwoven plastic fibers supported on both sides by cardboard panels that were perforated with 1 in. diameter cut-outs. There were 57 such cut-outs in the cardboard panels, providing an effective filter area of 0.311 sq ft.

The 4-blade propeller fan, 6 in. in diameter, was installed behind the center of the front grille on the shaft of an electric motor. A Westinghouse "Odorout" lamp was mounted on

either side of the fan. These lamps were shielded from the front grille by steel sheets. The lamps were wired in series with one another and with the fan motor. They were manufactured by the Westinghouse Electric Corporation and had a nominal rating of 0.350 amperes at 10 to 12 volts. This implied that the fan motor would operate at about 90 volts and 32 watts.

Figure 1 is a photograph of the test specimen showing the front grille with the ornamental name plate and the on-off switch. The tag of the Bureau of Medicine on top of the cabinet identified the test specimen as follows: P.S. 11-445R 9/8/60 DJV.

3. DESCRIPTION OF TEST

3.1(a) Determination of Air Flow Rate with a Clean Filter

The effective area of the outlet grille was the center portion of the perforated face of the apparatus and had a 6-inch diameter. It was found that the air velocity was not uniform near the face of the grille, and it was necessary to determine the velocity at a large number of stations some distance away from the outlet grille in order to avoid the effect of the vortices generated at the perforations in the grille.

A cardboard collar 6 inches in diameter was attached to the face of the device coinciding with the effective area of the outlet grille. The length of this collar was 3 inches, and it was sealed against the surrounding portion of the grille with masking tape to prevent any side leakage of air.

The velocity pressure of the air stream was then determined with a standard Pitot tube and an inclined manometer which could be read to the nearest 0.001 in. W.G. The nozzle end of the Pitot tube was 6 inches long, thus avoiding a disturbance of the air flow by the shank of the tube. Pitot tube readings were taken 1/2 in. apart, vertically and horizontally, over the outlet plane of the collar, i.e., 3 in. from the outlet grille. The total air flow rate of the unit, Q (cfm), was then computed as the sum of the air flow rates, q (cfm), determined for each of the individual areas represented by the respective points of measurements. Each area was considered to be one-half inch square and a total of 112 areas were used. The following formula was developed for the air flow rate:

$$Q = \Sigma q \text{ (cfm)}$$

where: $q = a \times v$ (cfm)

$a = (1/2 \times 1/12)^2$ (sq ft)

$v = 4005 \times \sqrt{h}$ (ft/min) for dry air at 70°F and 29.92 in. Hg. pressure

h = the velocity head determined near the center of each 1/2-in. square (in. W.G.)

Therefore:

$$Q = \Sigma \left[(1/2 \times 1/12)^2 \times 4005 \times \sqrt{h} \right]$$

or

$$Q = (1/2 \times 1/12)^2 \times 4005 \times \Sigma\sqrt{h}$$

$$Q = 6.951 \times \Sigma\sqrt{h}$$

Positive velocity pressures could be observed in 100 incremental areas. No velocity pressure could be observed on the inclined manometer in 12 positions near the center of the outlet grille. At some positions, the deflection of the manometer appeared to be slightly negative, indicating some aspiration in this portion of the outlet. In the computation of the air delivery, it was assumed that no flow existed in the 12 squares where no velocity pressure could be measured.

Figure 2 shows the arrangement of the 112 squares and the velocity heads observed in these with the Pitot tube. The value $\Sigma\sqrt{h}$ was computed by multiplying N, the number of squares in which a velocity pressure, h', was observed, by the square root of this velocity pressure and then adding the products $N \times \sqrt{h'}$, as follows:

h', in. W.G.	N	N x $\sqrt{h'}$
0.001	44	1.392
0.002	10	0.447
0.003	6	0.328
0.004	5	0.316
0.005	2	0.141
0.006	3	0.232
0.007	6	0.502
0.008	5	0.447
0.009	2	0.190
0.010	4	0.400
0.011	1	0.105
0.012	3	0.329
0.013	1	0.114
0.014	1	0.118
0.015	1	0.123
0.016	2	0.253
0.018	3	0.403
0.019	1	0.138
	100	5.978

$$Q = 6.951 \times 5.978 = 41.5 \text{ cfm.}$$

The error in this evaluation of the total flow rate is considered to be 10 percent or less. A thermocouple anemometer was also used to measure the air flow rate and was found to agree with the values obtained with the Pitot tube although the thermocouple anemometer is known to have a lower accuracy under these test conditions.

3.1(b) Determination of Air Flow Rate with a Loaded Filter

After the filter had been loaded with Cottrell precipitate, as described below, the air flow rate was again determined. However, no indicative measurements could be made with the Pitot tube. An air velocity of 100 ft/min corresponds to a velocity pressure of 0.00067 in. W.G., which was below the sensitivity of the inclined manometer available for this test. A maximum deflection of the manometer of approximately 0.001 in. W.G. could be observed at only a few stations. Therefore, the air velocity under this condition was observed with the thermocouple anemometer. The air velocities observed with the thermocouple anemometer ranged from 40 ft/min to 110 ft/min. The average

velocity was determined to be no more than 90 ft/min corresponding to an air flow rate of approximately 18 cfm. The dust load of the filter was 30.7 grams for this test.

3.2 Determination of Arrestance

Arrestance determinations were made by the National Bureau of Standards Dust Spot Method using the particulate matter in the laboratory air as the aerosol. The test method is described in the paper, "A Test Method for Air Filters," by R. S. Dill (ASHVE Transactions, Vol. 44, p. 339, 1938). The test specimen was operated on 115-volt electric service. One dust sampler was placed near the inlet and the other was placed so that effluent from the center of the outlet grille was aspirated 3 in. from the grille. Air was sampled at equal rates through equal areas of Whatman No. 41 filter paper. Whereas the downstream sample was operated continuously, the upstream sample was operated only 80% of the time in order to obtain a similar increase of opacity on both sampling papers. The change of opacity of the dust spots on the two sampling papers was determined with a sensitive photometer which measured the light transmission of the same areas on each paper before and after the test. The two sampling papers used for each test were selected to have the same light transmission readings when clean. The arrestance, A (in percent), was then calculated by the formula:

$$A = 100 - T \times \frac{\Delta D}{\Delta U}$$

where T equals the percentage of the sampling cycle during which air was drawn through the upstream sample; ΔD and ΔU, the change in opacity of the downstream and upstream sampling papers, respectively. Two arrestance tests, each lasting approximately 2 hours, showed arrestance values of 15.1 and 14.0%, respectively, indicating an average arrestance of 14.6%. The relative humidity in the laboratory during these tests was approximately 55%.

3.3 Removal of Ragweed Pollen and Tobacco Smoke

After making the arrestance tests, but prior to loading the filter with Cottrell precipitate, a strip of cellophane tape was fastened to the collar, the sticky side facing the outlet grille, located approximately along the horizontal diameter of the outlet collar. Ragweed pollen was introduced into the test specimen for a short time. A microscopic examination of the cellophane

tape clearly indicated that a considerable amount of ragweed pollen had passed through the device. The pollen was clearly identified on the cellophane tape with a microscope at moderate magnification. It was observed in abundance on every field examined by the microscope.

When tobacco smoke was blown from the mouth of a staff member toward the filter of the operating test specimen from a distance of about 1 foot, this smoke could be seen in the effluent air stream with the unaided eye and its odor was perceptible.

4. CONCLUSIONS AND DISCUSSION

(a) The air delivery of the test specimen was 41.5 cfm ±4 cfm when the filter was clean and no more than 18 cfm when the filter was loaded with 30.7 grams of Cottrell precipitate.

(b) The arrestance of particulate matter in the laboratory air averaged 14.6 percent from two tests at a relative humidity of approximately 55 percent.

(c) Ragweed pollen penetrated the device in considerable numbers as indicated by the microscopic examination of cellophane tape that had been exposed at the outlet when such pollen were sprayed against the filter.

(d) Tobacco smoke blown toward the filter of the operating test specimen could be seen in the effluent air stream with the unaided eye and its odor was perceptible.

An advertizing folder for "Sunflo" states that the Model SF-2 recirculates the air in an average-size room every 20 minutes or so. An average-size room is quoted in the same folder as having up to 1800 cu ft volume. Based on a 20-minute recirculation of the air in a room having a volume of 1800 cu ft, the claimed air circulation rate would be 90 cfm.

A calculation can be made to determine how much the "Sunflo" could reduce the concentration of the particulate matter in a room of this size with an outdoor air leakage of 1 air-change per hour and with the assumption that no dust was being generated in the room, as follows:

If C_o is the concentration of particulate matter in the outdoor air per unit volume, the total particulates entering the room per minute would be

$$\frac{1800}{60} \times C_o = 30\ C_o$$

If C_1 is the steady state concentration of particulates in the room after the "Sunflo" has been operated for a sufficiently long time, the sum of the particulates leaving the room by leakage and being collected by the "Sunflo" device per minute would be

$$30\ C_1 + (41.5 \times 0.146 \times C_1)$$

assuming that the device was circulating 41.5 cfm and had an arrestance of 14.6 percent.

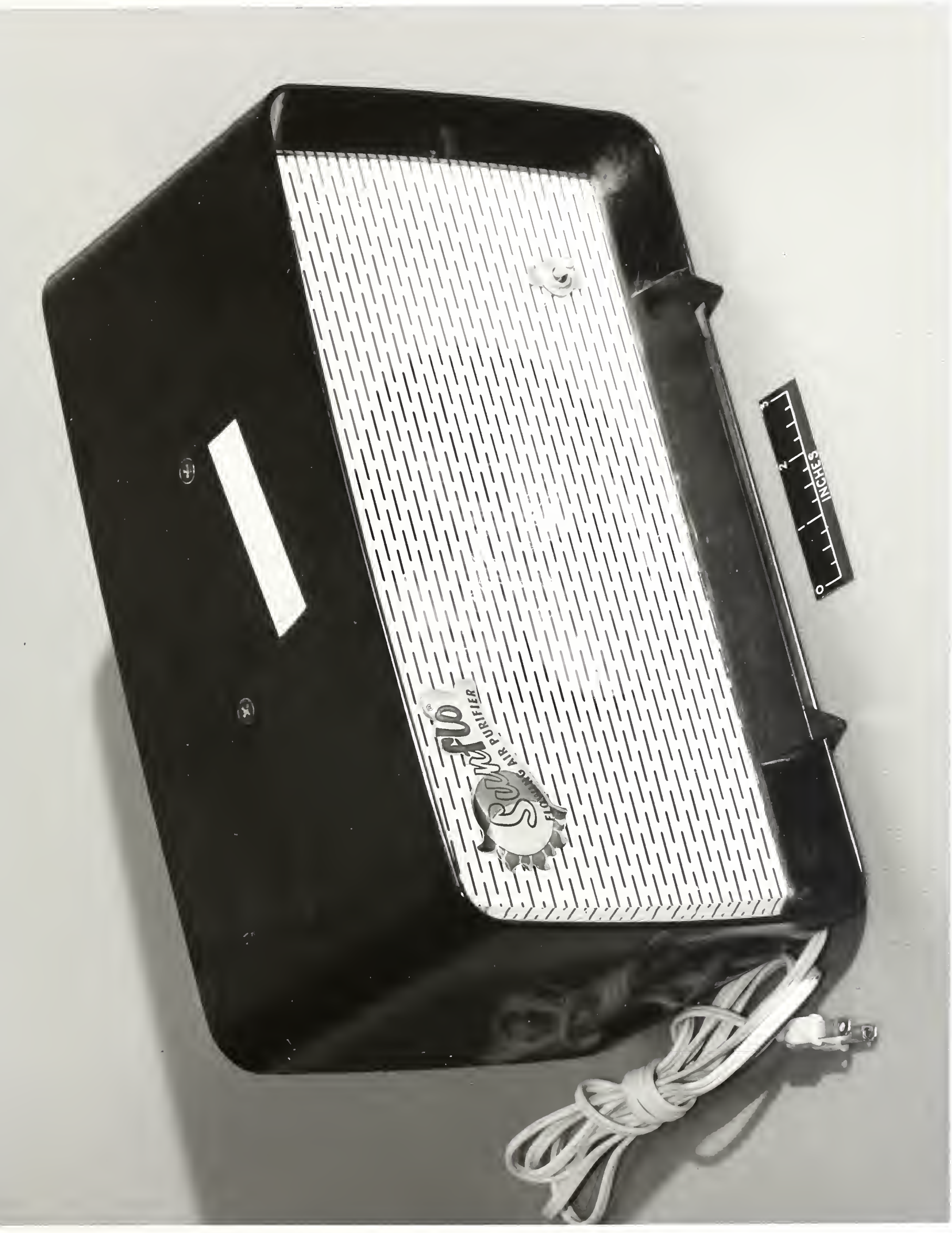
At steady state conditions, the total rate of entry and removal of particles would be equal and

$$30\ C_1 + 41.5 \times 0.146 \times C_1 = 30\ C_o$$

or

$$C_1 = 0.83\ C_o$$

This example indicates that the concentration indoors would be 17 percent less than that outdoors under steady state conditions. This is the best performance that could be expected, since any production of dust inside the room would result in greater indoor dust concentration than that determined for the example.


AIR PURIFIER
INCHES

PATTERN OF VELOCITY PRESSURES OF EXHAUST AIR STREAM
FROM A 6-IN. DIAMETER GRILLE DETERMINED WITH A CLEAN FILTER,
VALUES IN 0.001 IN. W. G.

				8	5	4	4				
		10	7	2	2	3	4	6	7		
	12	7	2	1	1	1	1	2	6	10	
	8	2	1	1	1	1	1	1	2	6	
16	8	3	1	1	-	-	1	1	1	2	13
18	5	1	1	-	-	-	-	1	1	1	12
18	3	1	1	-	-	-	-	1	1	1	16
14	4	1	1	1	-	-	1	1	1	3	18
	10	2	1	1	1	1	1	1	1	7	
	12	4	1	1	1	1	1	1	7	15	
		10	7	3	2	2	3	8	19		
				10	8	9	10				

Figure 2

U.S. DEPARTMENT OF COMMERCE
Frederick H. Mueller, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colo., is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D.C.

ELECTRICITY. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics.

METROLOGY. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

HEAT. Temperature Physics. Heat Measurements. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research. Equation of State. Statistical Physics. Molecular Spectroscopy.

RADIATION PHYSICS. X-Ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

CHEMISTRY. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

MECHANICS. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Combustion Controls.

ORGANIC AND FIBROUS MATERIALS. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

METALLURGY. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

MINERAL PRODUCTS. Engineering Ceramics. Glass. Refractories. Enameled Metals. Constitution and Microstructure.

BUILDING RESEARCH. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials.

APPLIED MATHEMATICS. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

DATA PROCESSING SYSTEMS. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Applications Engineering.

ATOMIC PHYSICS. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics.

INSTRUMENTATION. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Office of Weights and Measures.

BOULDER, COLO.

CRYOGENIC ENGINEERING. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

IONOSPHERE RESEARCH AND PROPAGATION. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services.

RADIO PROPAGATION ENGINEERING. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation-Terrain Effects. Radio-Meteorology. Lower Atmosphere Physics.

RADIO STANDARDS. High frequency Electrical Standards. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time Standards. Electronic Calibration Center. Millimeter-Wave Research. Microwave Circuit Standards.

RADIO SYSTEMS. High Frequency and Very High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Space Telecommunications.

UPPER ATMOSPHERE AND SPACE PHYSICS. Upper Atmosphere and Plasma Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

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